Journal of Pedagogical Research
Volume 8, Issue 1, 2024
http://doi.org/10.33902/JPR.202400001

Research Article

Erratum to: Interrelationships of climate adaptation and organizational learning: Development of a measurement model

The Original Article was published on 6 December 2022.

Sophie Fischer[1], Michael Göhlich[2] and Jan Schmitt[3]

[1]*Institute of Digital Engineering, University of Applied Sciences Würzburg-Schweinfurt, Germany (ORCID: 0000-0002-8012-5967)*
[2]*Institute of Education, Friedrich-Alexander-University Erlangen-Nürnberg, Germany (ORCID: 0000-0002-7701-1475)*
[3]*Institute of Digital Engineering, University of Applied Sciences Würzburg-Schweinfurt, Germany (ORCID: 0000-0003-4537-7680)*

Climate adaptation and learning support organizations in coping with the current and projected impacts of climate change by identifying challenges as opportunities, ensuring business continuity and increasing their economic efficiency. In addition to material resources, climate adaptation requires knowledge, technical know-how and the ability to learn. Our article examines the relationship between climate adaptation and organizational learning, as the consideration of climate adaptation in the long term and with regard to organizational learning or reorientation is still very little represented in research. Therefore, a quantitative study is conducted in order to determine whether companies already have climate-related structures conducive to learning, whether they take responsibility for the learning object (climate change), and which elements limit the learning process. The survey of 288 companies and craft businesses in a German industrial region shows that intangible resources such as a sense of responsibility, a positive attitude among managers and shared values have a significant influence on how companies deal with climate change. Managers are key players in setting corporate goals, developing strategies and monitoring functional processes. The study shows that the number of climate-related measures taken is increasing due to higher resource capacities. As we draw conclusions about the changing learning requirements, conditions and media in the face of climate change, the results can provide relevant suggestions for researchers and practitioners to understand climate adaptation as a valuable and strategic challenge and to improve the resilience of the organization itself.

Keywords: Climate adaptation; Organizational learning; Corporate social responsibility; Organizational development; Organization education

Article History: Submitted 1 January 2024; Published online 30 January 2024

1. Introduction

The report published by the Intergovernmental Panel on Climate Change (IPCC] in March 2022 shows how climate change is progressing and how the 1.5-degree Celsius target defined in the Paris Agreement is receding ever further into the distance (Poertner et al., 2022). The associated

Address of Corresponding Author

Sophie Fischer, University of Applied Sciences Würzburg-Schweinfurt, Ignaz-Schön-Str. 11, 97421 Schweinfurt, Germany.

✉ xeniasophie.fischer@fhws.de

How to cite: Fischer, S., Göhlich, M., & Schmitt, J. (2024). Erratum to: Interrelationships of climate adaptation and organizational learning: Development of a measurement model. *Journal of Pedagogical Research, 8*(1), 223-243. http://doi.org/10.33902/JPR.202400001

consequences, such as increased average global temperatures and extreme weather events, are increasing and pose numerous and interlinked risks (IPCC, 2022; Federal Ministry for the Environment [BMU], 2020). As economic actors use energy and other resources and contribute to higher greenhouse gas emissions (BMU, 2020; Guetschow et al., 2016; Umweltbundesamt, 2022), they are required to deal responsibly and effectively with climate-related uncertainties and risks (Schoenbein et al., 2020; Statista, 2020). There are two mutually dependent approaches to tackling the negative effects of climate change: Climate mitigation and climate adaptation. Climate mitigation counteracts global warming by reducing carbon dioxide emissions. Climate adaptation is defined as an intervention to avoid economic damage while simultaneously increasing economic efficiency (Stocker, 2014). Corresponding strategies include both short-term interventions and strategic ones that can bring about comprehensive changes in organizational practices and also support organizational resilience in general (Berkes, 2007; Bowyer et al., 2014). Climate adaptation measures therefore start at different points in time: Reactive measures are designed to respond to a specific challenge or event, such as offering free drinks and appropriate breaks for employees on hot days. Anticipatory measures, on the other hand, are implemented at an early stage, for example through the planning and construction of energy-saving buildings, including technical protection devices (e.g. the installation of snow guards on roofs). Researchers around the world are recording climate adaptation efforts by companies, especially manufacturing companies (Meinel & Schüle, 2018; Linnenlücke et al., 2013; Kanyama et al. 2018; Nicoletti et al., 2019).

As climate adaptation refers to the ability and willingness to deal constructively with external changes, anticipate future developments and continuously adapt internal processes to these changes, there are further links to organizational learning. Organizational learning supports organizations in recognizing the associated challenges as opportunities, ensuring the continued existence of the company and increasing its profitability (see Argyris, 1976; Souza et al., 2020; Orsato et al., 2017). In the face of disruptive external change, the interest in learning in, by, and among organizations (Göhlich et al., 2018) within the scientific discourse is growing (Weber et al., 2011; Easterby-Smith & Lyles, 2003) as learning in organizations serves their continued existence, development, performance, and competitiveness (Cömlek et al., 2012; Feld & Seitter, 2018; Kim, 2021; Marsick & Watkins, 2003; Nicolletti et al., 2019; Souza et al., 2020). Especially, the German Organizational Education focus on organizational learning is increasing with interdisciplinary research (e.g., business studies, social sciences, psychology) and works by March and Olsen (1975), Argyris and Schön (1997), Nonaka and Takeuchi (1995) and Senge (1990) at the beginning of the 1990s, as Göhlich (2018) states. The initial position here is the consideration of organizations as complex social entities (Weber et al., 2019) which are confronted with highly dynamic changes of external environments. Organizations have to face unpredictable challenges and risks to maintain their efficiency and to ensure their economic existence.

In the context of organizational learning, leadership proves to be a relevant and significant determinant of employee behavior, their commitment to change and strategic goals in an organization (Nerdinger, 2014). Thus, studies on climate adaptation in organizational research often focus on the leadership level, as this is crucial for resources and the implementation of strategies or organizational realignment (Daddi et al., 2018; Mahammadzadeh et al., 2013; Meinel & Höferl, 2017; Meinel & Schüle, 2018). Further, studies that consider organizational learning processes in the context of climate adaptation usually focus on individual units, such as internal publications, life cycle management and management level (Bianchi et al., 2021; Nicoletti et al., 2019) or examine how climate adaptation is influenced by organizational learning capacities (Orsato et al., 2017). From this rather specific perspective on service instructions or environmental statements, the studies derive the extent to which, for example, the organizations surveyed deal with the topic of climate adaptation and which approaches have been chosen so far and how. In particular, the consideration of climate adaptation in the long term (i.e. anticipatory adaptation) and with regard to organizational learning or realignment is still very little represented in research (Orsato et al., 2017).

Thus, our paper examines the links between climate adaptation and organizational learning. Here, we focus on the question of which circumstances cause organizations to learn (Gnyawali & Stewart, 2003) or even "force" them to learn and which factors are conducive or inhibiting. First of all, it is crucial to identify previous adaptation efforts and their organizational design as well as the corresponding promoters and barriers. A quantitative survey is suitable for this in order to gain concrete insights. This study maps the extent and the processes, structures and individual steps that companies in the region under investigation have undertaken to initiate or implement adaptation measures and to identify (future) needs. The following research question is to be answered:

RQ1: How do the companies studied relate climate adaptation to organizational learning processes?

With our study we aim to map the interrelationships of elements of organizational learning and climate adaptation strategies and awareness with a quantitative survey. The results should provide an overview of relevant organizational units and approaches to change thinking and behaviours among economic actors. Furthermore, theorists and practitioners could use the identified fields of actions in order to deal with opportunities related to increasing the organization's resilience towards external crises. In the following, we provide an overview of the theoretical background to climate adaptation and organizational learning in order to explain our methodological approach. Section 3 then presents the research design and sections 4 and 5 describe and discuss the results in terms of learning and inhibiting and facilitating elements. In the conclusion, the results are summarized and implications for further research are outlined.

2. Theoretical Background

2.1. Key Actors within Climate Adaptation

Reactive and anticipatory climate adaptation acts locally and comprises individual measures or strategies to cope with existing and future impacts. As already mentioned, the studies examined focus strongly on the management level, as this is crucial for the development and implementation of adaptation strategies (cf. Eggers & Kaplan, 2009). Meinel and Schüle (2018) examined the barriers to anticipatory climate adaptation at the management level using supply chains in the manufacturing industry. From a theoretical perspective, they compare their assumptions with adaptive inaction and challenges for managers. Similar to Sump and Yi (2021) and Zollo et al. (2013), they identify the barriers to anticipatory climate adaptation. Orsato et al. (2017) distinguish between benefit-maximizing, behavioral and institutionalist climate adaptation. The former is about maximizing benefits through alternative raw materials, services, etc. The behavioral approach is about perceptions and attitudes towards adaptation and organizational realignment. The institutionalist approach, which is often taken up in research projects, is systemically oriented, i.e. adaptation is dependent on social, political and economic conditions (Orsato et al., 2017). Similar to Orsato et al. (2017), our findings emphasize the need for a systemic approach, which refers to adaptation that is consistent with direct (physical, human) and indirect (economic, regulatory) climate impacts. In-depth climate adaptation is characterized by the fact that it is a continuous process and is systemic, i.e. it involves the organization and its internal and external environment.

However, this strategic idea also requires the corresponding capacities, i.e. awareness of innovations, resources to implement technological and structural changes and, in particular, the promotion of internal and external transfer of experience and knowledge. It is also about the extent to which organizations in general have learning capacities and how existing processes, knowledge and structures can be changed. These characteristics can be transferred to organizational learning, as explained in the next section.

2.2. Measurability of Organizational Learning

According to Luhmann's system theory (1994) an organization represents a closed system that operates independently and follows its own logics and models of meaning which constantly recreate themselves. In this system-theoretical approach, 'system' and 'environment' are differentiated and the analysis of organizations is carried out holistically corresponding to the habitus, the actions, the members, and the environment, which are all in a reciprocal relationship to each other. Consequently, the conglomerate of these interrelationships, decisions, communication, values, rules, and other determinants of impact constitutes organizations. Such a perspective also makes it difficult to develop a unified concept of organizational learning, as the implicit and explicit learning processes cover the entire set of impact relationships and are difficult to reduce to single 'factors' or 'impulses'. With a behaviourist understanding of learning, i.e., a behavioural change as a result of external stimuli (Göhlich et al., 2018), March and Olsen define organizational learning as an adaptation process. Organizations learn from experiences which they observe, reflect and modify for subsequent actions (Göhlich et al., 2018). Further, Senge's 'Fifth discipline' guides many modern management theories and it is more applicable than other learning theories (Göhlich et al., 2018). Referring to systems thinking, Senge defines learning as a rethinking process. Here, he indicates the five core disciplines of personal mastery, mental models, shared vision, and team learning (Schlüter, 2018; Senge, 1990; Souza et al., 2020). His assumption is that organizational learning is initially a theoretical construct or vision which is driven by organizational members in a processual manner by evolving successively to achieve their goals (Schlüter, 2018).

In the organizational learning process, specific changes in mental models - in which processes, structures, and actions are processed reflexively and mimetically - are more appropriate (Göhlich & Zirfas, 2007). However, the measurability of such initially incidental changes and knowledge (Nonaka & Takeuchi., 1995; Marsick & Watkins, 2003) is complex and may be deficient. There are a large number of questionnaires in the literature for operationalizing organizational learning, but no measurement model based on indicators of organizational learning with regard to climate-relevant measures. In general, organizational learning is difficult to measure and consider in absolute terms due to the large number of interactions and influencing factors. A validated model is the 'Dimensions of Learning Organization Questionnaire" [DLOQ] by Marsick and Watkins (2003) to measure learning organizations and derive strategies for developing the organizational learning culture. The model refers to several indicators defined by Marsick and Gephart (2003) that an organization needs in order to adapt to dynamic organizational environments in an integrative and effective way (Delios & Beamish, 2001). In addition to the organizational framework conditions, Marsick and Gephart (2003) name internal and external communication, innovation capability, collective learning and the accumulation of knowledge and expertise as core elements. Based on the DLOQ (Marsick & Watkins, 2003), we derived five scales as indicators for organizational learning in connection with climate adaptation in our developed measurement model (see Section 3.2, Table 2): Innovation, error management culture, collaborative learning, learning through others, corporate social responsibility.

Here, the "Innovation" dimension refers to the requirement to analyze and dynamically adapt to external change with market-driven changes and product and service requirements. Dealing with mistakes ("Error management culture") is highly relevant for organizational development processes and their individual innovative capacity (Fischer et al., 2018). Internally, for example, a constructive error culture and flat communication systems should be cultivated through which needs, change requirements and error and learning experiences can be shared with managers and employees. The "Shared vision" scale, adopted from Lloria and Moreno-Luzon (2014), deals with a shared vision within the company and a shared understanding of climate-related goals and measures. As mentioned earlier, managers are responsible for setting organizational goals, developing strategies and monitoring functional processes, as they play a key role in deciding how to deploy resources. Furthermore, knowledge sharing can be one of the key elements in identifying

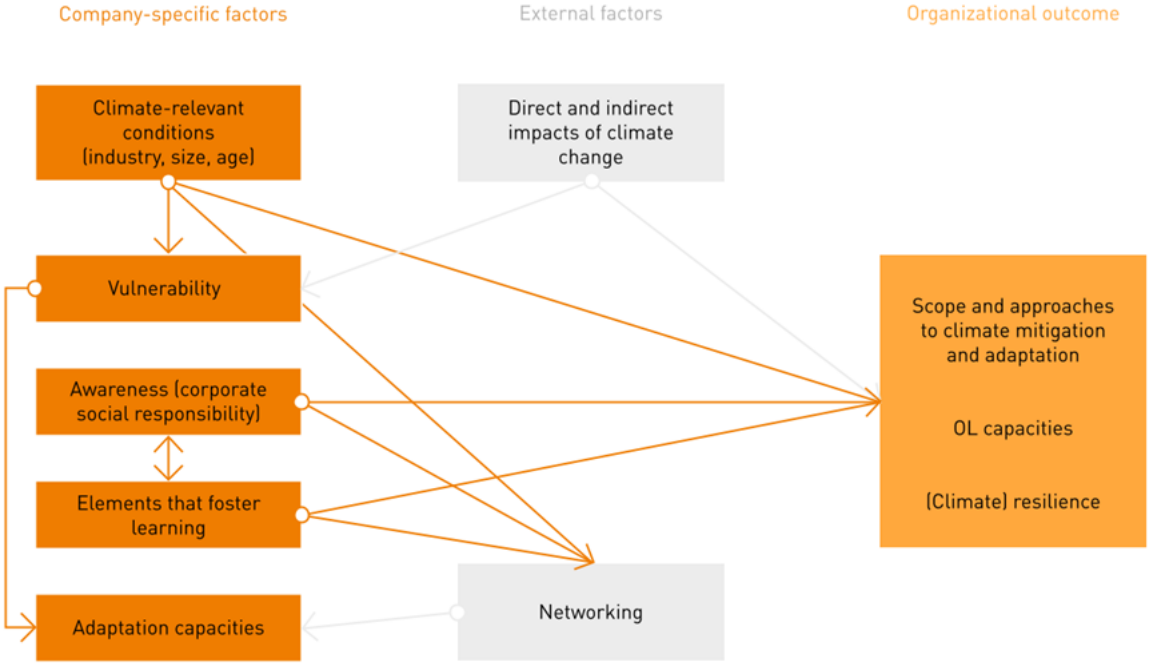
internal company barriers and eliminating divergent perceptions and weightings of climate change. Thus, the "knowledge acquisition" scale, modified according to Moreno-Luzon (Lloria & Moreno-Luzon, 2014), is intended to map the extent to which companies have (personnel, technical, organizational) structures in place to share knowledge and experience across disciplines. It is also necessary that learning experiences are documented and made accessible to all employees in order to increase organizational learning. The "Learning from others" scale is intended to show the extent to which the companies are oriented towards similar or foreign companies and have already introduced external impulses from third parties such as authorities and experts. It is also intended to assess how important the fundamental exchange with other companies is for the company. "Participation" means incorporating the concrete knowledge, experiences and needs of employees into application-oriented strategies and not just taking a top-down approach.

2.3. Connections between Climate Adaptation and Organizational Learning

Organizational learning requires the integration of individual knowledge and experiences (Gherardi, 2013). While organizations initially face different framework conditions, they increasingly have to deal with climate change's direct and indirect effects. Decisive for the strategic integration of the topic of climate change in an organization are the framework conditions such as the number of employees and turnover, but also intangible influencing factors such as organizational awareness or the attitude of managers. Thus, based on the literature and expert interviews analyzed using the grounded theory method (published in Fischer et al., 2022), we developed a conceptual model to illustrate internal and external factors that influence organizations in the face of climate change (see Figure 1).

Figure 1

Conceptual model of the relationship between internal and external drivers in dealing with climate change



Note. Own figure based on expert interviews (Fischer et al., 2022) and literature according to (Ameling et al., 2012; Bianchi et al., 2021; Hurrelmann et al., 2018; Kind et al., 2015; Mahammadzadeh et al., 2013; Orsato et al., 2017;).

The model illustrates that climate-related changes in economic conditions lead to a need for adaptation and increased demands on learning capacities in order to enable sustainable organizational development. It also illustrates the internal and external influencing factors associated with organizational adaptation. As we want to map the links between climate adaptation and organizational learning, we only analyze elements of organizational learning within the dynamics of climate adaptation. In this context, the model includes elements such as capacity and vulnerability as well as facilitating factors such as awareness, networking with third

parties and structures that promote learning. The arrows illustrate the individual interactions that lead to the hypotheses listed below, which relate to the derived dimensions and scales of the measurement model (see section 3.2). The hypotheses include intangible aspects of climate adaptation that, according to the literature and expert interviews, have an increased influence on how organizations deal with climate change. First and foremost, it is about the extent to which the companies and craft enterprises examined have structures that are conducive to learning, i.e. the extent to which the derived scales are pronounced:

- *$H1_1$:* A positive climate-related attitude of executives corresponds with climate-related structures conducive to organisational learning.
- *$H1_2$:* Structures conducive to organisational learning correspond with the adaptation capacities of companies and handicraft companies.
- *$H1_3$:* Executives and structures conducive to learning have a positive influence on the adaptation capacities of companies and handicraft companies.

Our brief theoretical outline serves as a starting point for our subsequent analyses and development of a measurement model to identify climate-relevant indicators of organizational learning.

3. Methods

3.1. Research Design

Since climate adaptation has to take place on a local level and in each organization separately, our analysis considers companies and handicraft companies in a strongly industrialized Bavarian region where the average warming rates are already above the national average (Rauh & Paeth, 2011). Thus, we analyse to what extent the companies in the examined region already have climate-related structures conducive to learning, to what extent they take responsibility in terms of the learning object (climate change), and which elements prove to be limiting here. Moreover, we examine how far the issue of climate change is being incorporated in a strategic manner and which inhibitions and limitations affect this kind of organizational change process.

To answer our research question, we conducted a regional study which is nourished by triangulating methods through results from regional climate data, expert interviews, and semi-standardized questionnaires. The expert interviews and the questionnaires were collected from June 2021 to January 2022. Since the results of climate models and expert interviews were published within a pre-study (Fischer et al., 2022), we exclude the climate data and only briefly refer to the findings of the expert interviews.

3.2. Data Collection and Sample

In cooperation with leading trade associations, we were able to access a total of 6,030 member companies and craft businesses from all economic sectors represented in the Bavarian region. After a six-week survey phase, 288 valid questionnaires were evaluated. The estimated total number of companies and craft enterprises surveyed results in a response rate of 4.8%. According to the studies considered (see Theobald, 2017; Tuten et al., 2002), the response rate of online surveys is around 33% and is determined by several variables. However, we used several approaches to achieve the highest possible response rate, including advance notifications, reminder emails, a simple questionnaire design and a short completion time (12 minutes). Nevertheless, the empirical approach depends on the motivation of the sample, and the questionnaires probably did not reach as many companies as originally assumed.

We have selected a probabilistic sample of companies and craft enterprises in the northern Bavarian region, see Table 1. Small companies are classified here as companies with up to 49 employees and a turnover of up to 10 million euros. Medium-sized companies have up to 249 employees and a turnover of up to 50 million euros (see Günterberg & Wolter, 2002).

Table 1
Demographic data on companies (total sample n = 133) and craft enterprises (total sample n = 155)

	Companies	*Valid*	*Handicraft companies*	*Valid*
	Number	%	Number	%
Category				
Non-manufacturing	80	59.7	-	-
Manufacturing	52	38.8	-	-
Company age				
≤ 5 years	6	5.9	-	-
> 5 years	94	93.0	-	-
Size				
Microenterprise	19	18.8	81	64.3
Small company	19	18.8	-	-
Midsize company	24	24.0	32	25.4
Large company	37	37.0	8	6.4
Up to 100,000	-	-	14	11.1
100,000 to 250,000	-	-	25	19.8
250,000 to 500,000	23	22.7	15	11.9
< 2 million			-	-
2 to 10 million	17	17.0	33	26.2
10 to 50 million	18	18.0	-	-
> 50 million	33	33.0	-	-
Owner	49	49.0	118	76.0
Third-party	46	46.0	25	16.0

Note. The percentages refer to the number of respective responses and vary between n = 111 and n = 126.

As shown in Table 1, 80 companies in the non-manufacturing sector, 52 companies in the manufacturing sector and 155 craft enterprises were surveyed. Among the craft businesses surveyed, the finishing trade (29.2%), the main construction trade (27.4%) and the trade for commercial needs (15%) were most frequently represented. Of the companies in the non-manufacturing sector, most were in the other services and trade sectors (together 24%), while mechanical engineering (20.7%), metal production and processing, the chemical industry, the rubber and plastics industry and the construction industry were each represented by 10.3% of companies in the manufacturing sector.

Most of the 95.2% owner-managed and family-run companies are micro-enterprises (up to nine employees), accounting for 64.3 %. Around 6.4 % are medium-sized companies and 25.4% are small companies with up to 49 employees. The turnover range per financial year is most frequently between 500,000 and 1 million euros (26.2 %), followed by 19.8 % in the 100,000 to 500,000 euro and over 2 million euro ranges. Companies that generate up to 100,000 euros account for the smallest share at 11.1%. The majority of owner-managed and family-run handicraft companies (95.2%) are micro-enterprises with up to nine employees, with 64.3% of these companies belonging to this category, while 6.4% are medium-sized companies with up to 249 employees and the remaining 25.4% are small companies with up to 49 employees.

3.3. Measurement Model and Analysis

After the pretest, the data from 288 manufacturing/non-manufacturing companies and craft were analyzed using the mean of a scale together with a reliability analysis (Cronbach's alpha) to determine how reliably a scale (Risher & Hair Jr, 2017) depicts a variable, see Table 2. According to Taber (2018), it was assumed that Cronbach's alpha (α) must be above 0.7 to have a reliable value (Table 2). We then recoded each scale into a binary variable (agree and disagree) to obtain a concise tendency. Selected significance tests such as Pearson's R and multiple regression were used to test each hypothesis. The interpretation of the Pearson coefficient is that −1.0 indicates a strong

Table 2
Construct and scales of organizational learning related to climate change

Construct/Scale	*Adopted and modified from / Items*	*Reliability*
Innovation	Çömlek et al. (2012)	
Openness to technology	6.1.a) We explore relevant technological trends regularly 6.1 b) We are open to new technologies / business practices 6.1.c) We have concrete functional units / processes to analyze technological trends 6.1.d) We start to implement new technologies measures immediately after the evaluation	alpha = 0.8 (very good)
Error management culture	Lloria and Moreno-Luzon (2014); Iqbal and Ahmad (2021)	
Coping with failures	7.2.a) Errors will be analyzed and communicated to all employees 7.2.b) Errors are considered as constructive learning experiences 7.2.c) We foster a positive error culture 7.2.d) Our management admits and communicates its own mistakes	alpha = 0.9 (excellent)
Collaborative support	Lloria and Moreno-Luzon (2014)	
Learning through experiences	7.2.e) We derive our own need for action from crises experienced by other companies 7.2.f) We use our experience from past crises in dealing with climate change	alpha = 0.72 (acceptable)
Corporate culture, Leadership	Lloria and Moreno-Luzon (2014)	
Shared vision	8.1.a) We consider a common point of view as important 8.1.c) We have a common understanding of climate-related objectives across the entire company	alpha = 0.83 (very good)
Attitudes	8.1.d) Our leadership/management level addresses and communicates the need for climate-related action internally	
Collaborative learning	Lloria & Moreno-Luzon (2014)	alpha = 0.7 (acceptable)
	8.1 b) We regularly exchange knowledge and experience (e.g. within working groups)	
Knowledge acquisition	Nicoletti et al., (2019); Marsick and Watkins (2003)	
	8.1.e) We have specific contact persons / functional email addresses etc. to whom employees can communicate their ideas	
Incentive systems	8.1.f) We have concrete incentive systems (e.g. prizes) to motivate employees to communicate their ideas	alpha = 0.83 (very good)
Information and knowledge management	8.1.g) We document knowledge / learning experiences Information and knowledge management and make it available internally to all (e.g. in newsletters, annual report) 8.1.h) We have concrete processes / databases to make collected knowledge accessible internally	

Table 2 continued

Construct/Scale	*Adopted and modified from / Items*	*Reliability*
External support	Lloria & Moreno-Luzon (2014)	
Learning through others	9.1.a) We orient ourselves in climate adaptation to companies from the same sector	
	9.1.b) We orientate ourselves in climate adaptation to companies from other sectors.	
	9.1.c) We are networked with other companies and / or exchange information regarding climate change	alpha = 0.84 (very good)
	9.1.d) We have / plan cooperations with institutions (e.g. research field) to learn more about the issue	
	9.1.e) We integrate external impulses into the development of processes / products / services.	
Responsibility	Montada et al. (2014)	
Corporate social responsibility	10.2.a) Our company is open to obtain information about environmental problems (e.g. air pollution)	
	10.2.b) Our company is open to actively seek new scientific knowledge about the extent of and solutions to environmental problems.	alpha = 0.93 (excellent)
	10.2.c) Our company is open to invest in the installation of environmentally friendly equipment (e.g. photovoltaics)	
	10.2.d) Our company is open to spend more money on products / raw materials / services if they are produced in a more sustainable way than comparable products / raw materials / services.	

Note. The table derived from the expert interviews and reference literature (Cömlek et al., 2012; Lloria & Moreno-Luzon, 2014; Montada et al., 2014; Nicolletti et al., 2019). After pretesting, item reliability (Cronbach's alpha) was tested and optimized. Own table, conceptual idea adopted from (Teo et al., 2006).

inverse relationship, 0 no relationship and +1.0 a strong direct relationship between the variables (Merthler et al., 2021). Due to a target group-specific design (in terms of length and items), fewer scales were asked for the craft enterprises. A questionnaire with 39 items, including three filter questions, was constructed for manufacturing and non-manufacturing companies (see Appendix A). The version for craft enterprises contains 22 questions with two filter questions. The questionnaire for the craft enterprises contained the same questions and the same structure in a compact form. Therefore, the hypotheses for the craft enterprises differ slightly from those for the companies.

For the conceptual model we adapted Marsick and Watkins (2003) dimensions related to organisational learning. Based on this, existing scales from the literature dealing with climate-related topics were selected and adapted according to the dimensions of Marsick and Watkins (2003). The questionnaire developed in this way is intended to investigate the extent to which learning-promoting aspects are present in the companies surveyed and whether these learning-promoting aspects are also perceived and used in relation to climate-relevant topics.

The collected questionnaires were first analysed descriptively using SPSS statistical analysis software (cf. Fischer & Schmitt, 2022). For this purpose, the data sets were first exported and cleaned. Invalid answers were marked, and the free text answers were sorted. Variables intended to represent latent characteristics such as climate awareness were combined into a scale using the mean value method. Reliability analysis (Cronbach's alpha) was used to check how reliably this scale depicts a variable, so that individual questions (items) could be omitted if necessary. Once all question and response formats were available in accordance with the required data level, the descriptive data was analysed first. The hypotheses were then tested using Pearson's correlation and multiple regression.

4. Results

4.1. Descriptive Results

The companies and craft businesses surveyed are increasingly struggling with the direct and indirect effects of climate change. In both groups, heat, heavy rain, flooding and high water were the most frequently cited impacts. The analysis of the regional climate model REMO also shows that average temperatures will continue to rise (Fischer et al., 20222). In addition to the direct impacts, the most frequently cited impacts across the entire sample are the increase in the price of raw materials and other resources or entire failures within the supply chain. However, it is not possible to clearly determine whether these effects are caused by climate change or other crises or bottlenecks. Regulatory requirements imposed by politicians are also perceived and affect larger companies to a slightly greater extent. In general, there are also significant market regulatory fluctuations and changes in market demand.

Based on the relevant dimensions derived from the literature and the expert interviews (see Fischer et al., 2022), implications for existing learning and adaptation capacities should be derived. As shown in Table 3, we map the results using the mean (M) and standard deviation (SD). Our results show that adaptation can take place in individual areas or behaviours. One example of this is managers who act as role models or encourage the restructuring of processes. Climate adaptation as an organisational learning process requires the involvement of leaders and management, individuals and teams, internal and external networks, work resources and processes, and organisational culture. As shown in Table 3, the mean values of the learning-enhancing elements in relation to climate adaptation are similar between companies and craft enterprises, with the exception of minor differences in "coping with failure" and "corporate social responsibility", where craft enterprises are weaker. The results show that the companies and craft enterprises surveyed already have climate-relevant structures in place with regard to learning, knowledge transfer, motivation and participation. However, the values around 3.0 show that these structures are only moderately developed and that there is still room for improvement.

Table 3
Mean values, standard deviation and number of cases (n) for the scales queried for manufacturing (M), non-manufacturing (NM), and handicraft companies (H)

	Companies	*Valid cases*	*SD*
Innovation			
Technology openness	M/NM	3.0 (n = 113)	1.0
Technology openness	H	3.0 (n = 113)	1.2
Error management culture			
Coping with failures	M/NM	2.5 (n = 106)	1.0
Coping with failures	H	2.4 (n = 114)	1.0
Collaborative support			
Learning through experience	M/NM	2.9 (n = 105)	1.0
Shared vision	M/NM	2.7 (n = 86)	1.2
Participation	H	3.0 (n = 112)	1.4
Executives			
Attitudes	M/NM	2.8 (n = 96)	1.3
Attitudes	H	2.9 (n = 106)	1.4
Collaborative learning			
Knowledge accumulation	M/NM	3.0 (n = 100)	1.3
Incentive systems	M/NM	3.2 (n = 99)	1.7
Information and knowledge management	M/NM	3.0 (n = 88)	1.2
External support			
Learning through others	M/NM	3.1 (n = 102)	1.2
Learning through others	H	2.1 (n = 127)	1.0
Awareness			
Corporate social responsibility	M/NM	2.5 (n = 133)	1.0
Corporate social responsibility	H	3.1 (n = 112)	1.3

Note. A six-point Likert scale (1 = strongly agree to 6 = totally disagree) was provided and supports mean averaging through the symmetrical response format, own table.

4.1.1. Indicators of learning versus volume of climate relevant measures

The questionnaire for companies contained sections with questions on general, structural and technological climate-relevant measures (multiple choice answers). In general, the companies implemented an average of M = 5.8 (n = 111) measures. Those companies that had already experienced damage costs due to climate change (n = 23) implemented an average of M = 7.5 of the measures listed. Small and medium-sized companies implemented an average of M = 2.2 and M = 2.6 of the nine measures listed, while large companies implemented an average of four measures. Finally, the binary variables formed in each case for the indicators that promote learning are compared with the total number of climate change mitigation and adaptation measures reported by the companies and craft enterprises, see Table 4.

The key figures succinctly show that companies that declare their willingness to have the learning-promoting structures in question implement more of the measures than companies that reject the topic. This result underlines the connection between structures conducive to learning and the extent of climate protection and adaptation measures. The average measures of the craft enterprises in terms of approval and rejection of the OL indicators are almost identical. The extent to which this result corresponds to reality or indicates irregularities in the data needs to be discussed here. These and other considerations regarding the results are discussed below in the context of answering our research question.

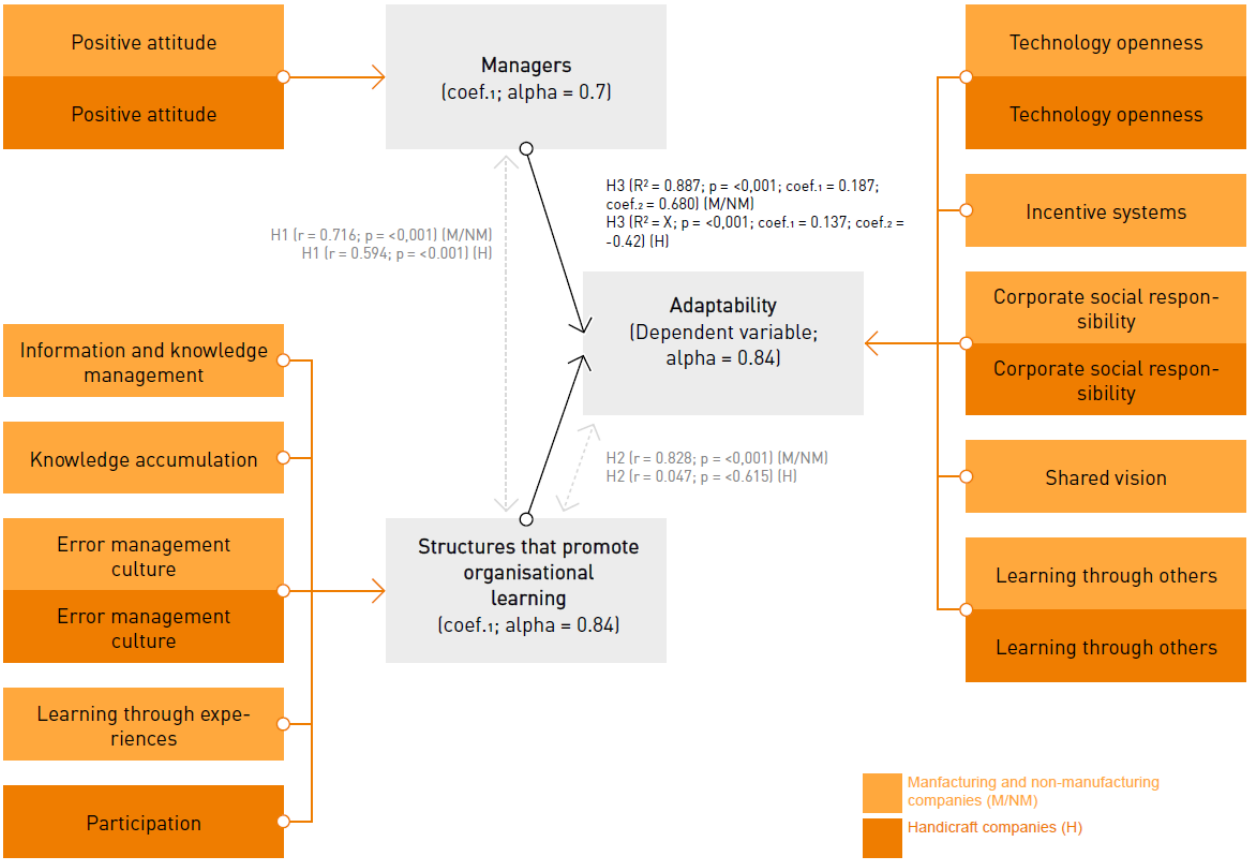
Table 4
Derived indicators conducive to learning, which were recoded into binary variables, versus mean measure volume of companies (total of 25 measures) and handicraft companies (total of 9 measures) by cross-tabulation, own table

		Measures taken (mean value)	
Dimension	*Type*	*Agreement*	*Disagreement*
Technology openness	M/NM	6.1	3.1
	H	2.5	2.5
Error management culture	M/NM	5.8	4.0
	H	2.5	2.5
Shared vision	M/NM	6.7	5.1
Participation	H	2.5	2.5
Knowledge accumulation	M/NM	7.1	4.6
Learning through others	M/NM	6.9	5.2
	H	2.5	2.0
Corporate social responsibility	M/NM	6.7	1.6
	H	2.5	2.5

4.2. Inference Statistical Results

In addition to the analysis of the maturity level of climate adaptation and existing capacities, we tested three hypotheses for companies and craft enterprises to examine the relationships between the indicators that support organisations in dealing with climate change, see Figure 2.

Figure 2
Visualization of the independent (managers; structures that promote organizational learning) and dependent variables (adaptive capacities) and the associated hypotheses 1-3



Note. All results and deviations for the companies (M/NM) and craft enterprises (H) are differentiated by color.

4.2.1. Hypothesis $H1_1$

As shown in Figure 2, the variables 'managers" and 'structures that promote organisational learning' show a significantly strong positive correlation in manufacturing and non-manufacturing companies (r =0.716; $p < .001$). Thus, the alternative hypothesis $H1_1$ is accepted, which states that there is a positive correlation between the attitudes of managers and the structures that promote organisational learning. In addition, a significant and positive correlation between the two variables can be found in the craft enterprises (r =0.594; $p < .001$). Accordingly, $H1_1$ supports the assumptions from the expert interviews and the literature that managers have an important influence on the provision of suitable working environments and structures in organisations that are conducive to learning. These structures must be designed comprehensively to enable learning at both the individual and organisational level. In addition to their role model function and their professional responsibility, managers contribute to ensuring that employees can participate in the work process according to their abilities and potential. Particularly with regard to climate adaptation, the integration of all available information, knowledge and experience is advantageous in order to develop specific and practise-oriented concepts.

4.2.2. Hypothesis $H1_2$

The second alternative hypothesis ($H1_2$) also points to a significantly strong positive correlation between the variables 'structures that promote organisational learning' and 'adaptability" ($r = 0.828$; $p < .001$, see Figure 3). Accordingly, it is assumed that structures that promote organisational learning correspond to structures that contribute to climate adaptation and should generally be considered collectively and not individually in all change processes. For this reason, an organisation should analyse and adapt structures that serve the learning, development and change of an organisation as a whole holistically and not just with regard to a single event that might occur as a result of climate change, for example. We find a very weak positive correlation among craft enterprises, that is not significant, i.e. the alternative hypothesis is rejected. It is unclear to what extent the result is due to statistical irregularities, and it is important to remember that correlation analyses do not provide information about the causality of relationships.

4.2.3. Hypothesis $H1_3$

The last hypothesis ($H1_3$) was tested by multiple regression using SPSS, with interpretation of the constants, ANOVA and coefficients (coef), see Table 5. For the companies, the model has a significant explanatory quality and the regression of $R^2 = 0.887$ can explain 88.7% of the variance of the dependent variable 'managers" H3 (R^2 =0.887; $p < .001$; coef.1=0.187; coef.2 = 0.680). The assumed alternative hypothesis states that management and organisational structures that promote learning have a positive influence on the assessment of companies' adaptability. The model also has a significant quality for the craft enterprises and indicates that managers have a significant positive influence on the dependent variable, while 'organisational structures that promote learning' have a non-significant negative influence on the dependent variable, see Table 5. Accordingly, the third alternative hypothesis is also assumed for the craft enterprises.

The hypothesis tests thus indicate that there is generally a strong correlation between learning and adaptation and that the two concepts cannot be considered separately. Rather, it is important to focus on the facilitating and inhibiting elements in learning and adaptation processes, which are discussed in more detail in section 5. First, relevant indicators are compared with the scope of measures implemented by companies and craft enterprises.

Table 5
Results of the regression analysis differentiated in manufacturing /non-manufacturing companies and handicraft companies

Adaptation capacities		
	β	*Standard derivation*
Manufacturing/Non-manufacturing companies		
Executives	0.187	0.050
Structures conducive to organisational learning	0.680	0.068
p	<.001	
N	106	
R	0.887	
Handicraft companies		
Executives	0.137	0.054
Structures conducive to organisational learning	−0.42	0.064
p	<.001	
N	118	
R	0.262	

5. Discussion

Organizational learning is based on the learning and knowledge of members who know more than the organization itself. This is due to the fact that most actions and decisions are determined by the tacit knowledge of the members (Argyris & Schön, 1997; Nonaka & Takeuchi, 1995). It becomes clear that organizational learning occurs through an interplay of learning objects, learning agents and different modes. The exclusive focus on learning from a cognitivist perspective leaves out content-related aspects such as skill learning, life learning and learning to teach (Göhlich et al., 2018). Even the initially simple adaptations of behaviors (see single-loop learning) are not sufficient to promote strategic learning constitutions. However, the measurability of such initially incidental changes and insights (Nonaka et al., 1995; Marsick & Watkins, 2003) is complex and can be flawed as there are many factors influencing organizational learning, different learning agents and changing learning objects. In addition, learners are often unaware of where they are learning and the extent to which they take responsibility for the learning object. Therefore, based on our conceptual model derived from the literature, we identify influencing factors that affect scope of action, decision-making and climate-related attitudes. Here, we use various dimensions to illustrate the extent to which and the processes, structures and projects with which the companies and craft enterprises examined strategically anchor the topics of climate protection and climate adaptation.

5.1. Community and Practice

Looking at the interdependence between adaptability and structures that promote learning, it becomes clear how important it is to create a working environment in which all employees can participate with their decisions and experiences and contribute their individual skills and needs to the work processes, as Marsick and Watkins (2003) or Lloria and Moreno-Luzon (2014) also state. The networks and friendships between organizational members and those involved in the process are also relevant for organizational learning (Rupic, 2018). In general, the establishment of a positive error management culture is crucial (Fischer et al., 2018). Such a culture promotes discussion about misguided measures (maladaptations) or deficits in the implementation of new measures and general communication about learning experiences between employees. This is essential in order to utilize the skills of employees, as they are often confronted with concrete, climate-related challenges in their daily work. If a sustainable error culture views errors as constructive learning experiences, employees remain motivated to contribute ideas and make suggestions for strategies in their areas of work. In addition, targeted incentive systems can encourage employees and convince them of the relevance of the topic. Committed members of an

organization develop a common framework in which they influence each other's decisions and actions, benefit from their collective experience and tackle challenges cooperatively.

5.2. Importance of Executives and Corporate Social Responsibility

As the results show, managers are the main drivers for setting corporate goals, strategic development and monitoring functional processes. Climate-conscious companies or craft businesses generally cited managers, their own employees and social requirements as drivers for their adaptation measures, which were implemented accordingly to a greater extent. It should also be noted that, in addition to their more pronounced awareness, these types of companies generally also used scientific sources and connections to third parties (companies and experts) for their strategies and target development. According to the Institute for Ecological Economy Research (2012), the general climate-related availability of knowledge and data is very good thanks to extensive communication media. Nevertheless, there are differences between the companies surveyed in their ability to use this information and incorporate it into strategy development. Here, knowledge sharing can be one of the key elements to identify internal barriers and address the different awareness and importance of climate change related issues.

The consideration of managers in the promotion of organizational learning processes is important insofar as managers have the task of activating and motivating employees to participate in change processes and to actively contribute their climate-relevant knowledge and experience to these change processes. Furthermore, managers are responsible for the individual development of employees (cf. Michel et al., 2014), be it through further training or the implementation of focus groups in which employees can learn from each other and benefit from the experiences of others.

5.3. Innovation and Technologies

Our analyzes also show correlations between openness to technology and the measures implemented. Openness to technology, technological trends and innovative business methods as well as the ability to try out new methods and measures are considered criteria for organizational learning (Castro et al., 2013; Lopez-Cabrales, Real, & Valle, 2011; Marsick & Watkins, 2003; Nicolletti et al., 2019). This type of innovative ability is only moderately pronounced in companies and craft businesses. A general open-mindedness towards these topics could support the adaptability of companies with regard to the rapidly growing market for green tech, the increasing need for self-sufficient energy supply and the need to increase energy and resource efficiency in economic processes. In addition, respondents are aware that corporate strategies can still be optimized with regard to climate protection and corporate sustainability (Fischer et al., 2022). Furthermore, the general awareness of their own role of responsibility is certainly more pronounced. This awareness represents a key starting point for scientific and political institutions to close the aforementioned gaps among economic actors with targeted offers and increase the motivation to act. In this context, climate-related and reliable corporate communication structures are key factors in addressing climate-related issues in a more comprehensive and "institutionalized" manner (Mahammadzadeh et al., 2013).

5.4. Corporate Culture

The corporate culture with historically grown values and jointly developed visions also plays an important role in the adaptation process (based on a behavioural science approach, see Orsato et al. (2017)), as does the ability to learn and adapt (Mbah et al., 2021). A corporate culture is an organisational reference system that includes the values, guiding principles, behaviours, thought patterns, rules and regulations of a company (Hentze et al., 2005). It is also changed by leadership and at the same time shapes the extent to which values, guiding principles and beliefs are reflected (cf. Park & Kim, 2018) and incorporated into leadership behaviour. In this respect, the present study does not provide more precise key figures, an aspect that needs to be supplemented by subsequent projects.

5.5. Immaterial Learn and Adaptation Capacities

The study shows that the number of climate-related measures taken increases with the size of the company, which is probably due to higher resource capacities. Even if the difference between manufacturing and non-manufacturing companies in terms of the measures taken is not significant, it is clear that some measures are implemented primarily by larger companies. This applies, for example, to the reorganization of working conditions, such as changed working hours, areas of responsibility and further training opportunities, and can be explained by the greater financial viability of such measures as well as the existing scope for testing and adapting measures for their effectiveness. It is obvious that companies with corresponding functional positions that deal exclusively with climate issues are at an advantage.

We assume that climate change is a constant challenge for companies and that reactive adaptation is less effective than anticipatory adaptation, which requires a change in attitudes and awareness (Iturriza et al., 2020) as well as profound changes in economic activities. In this process of climate adaptation, all members of the organization are required to contribute their experience, knowledge and motivation to cooperatively strengthen the organization in the face of climate change, i.e. to increase its resilience. The goal for the companies studied in the field of climate adaptation must therefore be to increase their ability and capacity to learn in order to be competitive and ensure their long-term viability despite all the challenges described above. Increased adaptive capacity can be used to develop the organizational resilience needed to overcome these challenges. Climate adaptation can begin in individual areas of an organization, for example with initially simple measures such as the establishment of a climate-relevant function. In addition, concrete structures for internal and external exchange must first be created, management must set an example and take responsibility, employees must be motivated to communicate their knowledge and experience transparently and mistakes must be shared. Climate adaptation must be systemic in order to promote an organizational learning process that strengthens organizations to deal constructively with other uncertainties and challenges.

In relation to the research question, the results show that the entire sample is already dealing with climate change and that intangible factors such as a sense of responsibility, a positive attitude of leadership and shared values (see Orsato et al., 2017) have a significant influence on how companies deal with climate change. One caveat here is that it is not possible to clearly distinguish whether the structures conducive to learning, such as a positive error culture, openness to innovation and an external network, are only attributable to the topic of climate adaptation or are part of the fundamental "organizational equipment". Although the companies surveyed have structures and processes for deriving climate-relevant topics, tasks and goals, assigning them to specific functions and modifying them for specific purposes, these values are only in the mid-range. A comparison with the relevant literature shows that climate change is a difficult topic to differentiate and that it is more important to examine companies in terms of their resilience in a highly dynamic economic environment.

6. Conclusion

With increasing regulatory requirements for emission values and the use of renewable energies, the public pressure on companies to strategically integrate topics such as sustainability and climate protection into their processes is growing immensely. The derived measurement model and hypotheses were used to determine the extent to which adaptation to climate change takes place as part of an organizational learning process. It should be noted that no terminological differentiation was made between climate protection and climate adaptation, as it cannot be assumed that all respondents are familiar with both terms. Our study therefore focuses on the question of the extent to which companies and skilled trade businesses are preparing to strengthen their resilience in the face of climate change and the predicted uncertainties. Here, too, only tendencies and elements of organizational learning can be examined. Since the systemic analysis of organizational learning or even learning organizations is very complex due to the many influencing factors, levels and

implicit learning mechanisms or knowledge content, it requires mixed-methods and more ethnographic approaches. Therefore, our study is limited to indicators of organizational learning in relation to climate adaptation.

Climate adaptation refers to local climatic conditions that differ from those in other regions and countries. Standardized guidelines, such as global adaptation strategies, are therefore not suitable. In particular, the indirect effects of climate change pose a challenge for companies. The results of our study are transferable to different organizations, regardless of how far climate change has already progressed in their environment. It is undeniable that organizations worldwide need to adapt to global climate change by first analyzing their enabling and constraining conditions. Because, as our article underlines, organizational learning supports organizations in securing their existence and working effectively. Like the coronavirus pandemic or the war of aggression against Ukraine, climate adaptation can be an incisive external event that "forces" organizations to restructure and strengthens them to survive in the long term. However, an organization can only be effective in the long term if it establishes structures that promote learning processes and does not simply react to an event.

Our results show that managers can play a decisive role in determining which tangible and intangible resources can be used to support organizational learning processes. Further empirical research should therefore examine individual attitudes, framework conditions and learning needs of leaders and show how leadership development can be used to empower leaders to think and act in a climate-conscious way. In our further research, we are developing a simulation game specifically for this purpose. This constructivist approach to game development integrates the experiences and educational needs of the target group (functional heads of organizations).

As the economic framework conditions and certain uncertainties of climatic development and the occurrence of natural disasters or extreme events show, dealing with climate change will be mandatory for all actors in economic and ecological systems in the future. Those actors who address their precautions, opportunities and risks at an early stage and have structures and capacities for strategic learning processes will increase their climate resilience by reducing their vulnerability to uncertainties.

Author contributions: All authors have sufficiently contributed to the study, and agreed with the results and conclusions.

Funding: This work was supported by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection under Grant number 67DAS216.

Declaration of interest: No conflict of interest is declared by author.

References

Ameling, D., Bajorat, B., Brinker, W., Burger, R., Cramer, H. J., von Dohnanyi, K., ... & Pfister, P. (2012). *Anpassungsstrategien in der Klimapolitik* [Adaptation strategies in climate policy]. Springer Science+ Business Media.

Argyris, C. (1976). Single-loop and double-loop models in research on decision-making. *Administrative Science Quarterly,21*(3), 363-375. https://doi.org/10.2307/2391848

Argyris, C., & Schön, D. A. (1997). Organizational learning: A theory of action perspective. *Reis, 77/78*, 345-348.

Bianchi, G., Testa, F., Boiral, O., & Iraldo, F. (2022). Organizational learning for environmental sustainability: Internalizing lifecycle management. *Organization & Environment, 35*(1), 103-129. https://doi.org/10.1177/1086026621998744

Berkes, F. (2007). Understanding uncertainty and reducing vulnerability: lessons from resilience thinking. *Natural hazards, 41*(2), 283-295. https://doi.org/10.1007/s11069-006-9036-7

BMU. (2020). *Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit. Broschüre Nr. 10034. Klimaschutz in Zahlen. Fakten, Trends und Impulse deutscher Klimapolitik* [Climate mitigation in numbers.

Facts, Trends and Impulses of German Climate Policy]. Retrieved August 20, 2021 from https://www.bmu.de/publikation/klimaschutz-in-zahlen-2020/

Bowyer, P., Bender, S., Rechid, D., & Schaller, M. (2014). *Adapting to climate change: methods and tools for climate risk management.* Climate Service Center.

Castro, G. M. D., Delgado-Verde, M., Amores-Salvadó, J., & Navas-López, J. E. (2013). Linking human, technological, and relational assets to technological innovation: exploring a new approach. *Knowledge Management Research & Practice, 11*(2), 123-132. https://doi.org/10.1057/kmrp.2013.8

Çömlek, O., Kitapçı, H., Çelik, V., & Özşahin, M. (2012). The effects of organizational learning capacity on firm innovative performance. *Procedia-Social and Behavioural Sciences, 41,* 367-374. https://doi.org/10.1016/j.sbspro.2012.04.043

Daddi, T., Todaro, N. M., De Giacomo, M. R., & Frey, M. (2018). A systematic review of the use of organization and management theories in climate change studies. *Business Strategy and the Environment, 27*(4), 456-474. https://doi.org/10.1002/bse.2015

Delios, A., & Beamish, P. W. (2001). Survival and profitability: The roles of experience and intangible assets in foreign subsidiary performance. *Academy of Management journal, 44*(5), 1028-1038. https://doi.org/10.5465/3069446

Easterby-Smith, M. P. V., & Lyles, M. (2003). The blackwell handbook of organizational learning and knowledge management. Blackwell.

Eggers, J. P., & Kaplan, S. (2009). Cognition and renewal: Comparing CEO and organizational effects on incumbent adaptation to technical change. *Organization Science, 20*(2), 461-477. https://doi.org/10.1287/orsc.1080.0401

Feld, T. C., & Seitter, W. (2018). Weiterbildung/Erwachsenenbildung und Organisationspädagogik [Professional development/adult education and organizational education]. In M. Göhlich, S. Weber, N. Engel, & A. Schröer (Eds.) *Handbuch Organisationspädagogik [The handbook of organizational education]* (pp. 83-93). Springer. https://doi.org/10.1007/978-3-658-07512-5

Fischer, S., Frese, M., Mertins, J. C., & Hardt-Gawron, J. V. (2018). The role of error management culture for firm and individual innovativeness. *Applied Psychology, 67*(3), 428-453. https://doi.org/10.1111/apps.12129

Fischer, S., Keupp, L., Paeth, H., Göhlich, M., & Schmitt, J. (2022). Climate Adaptation as Organizational Learning: A Grounded Theory Study on Manufacturing Companies in a Bavarian Region. *Education Sciences*, 12(1), 22. https://doi.org/10.3390/educsci12010022

Fischer, S., & Schmitt, J. (2022). Regionalstudie Auswirkungen des globalen Klimawandels in Mainfranken: Grundlagenwissen, aktuelle Strategien und Bedarfe ansässiger Wirtschaft. https://doi.org/10.57714/fpkt-vt47

Gherardi, S. (2013). Is organizational learning possible without participation? In S.M. Weber, M. Göhlich, A. Schöer, C. Fahrenwald, & H. Macha (Eds) *Organisation und Partizipation* [Organisation and participation] (pp. 29–43). Springer.

Gnyawali, D. R., & Stewart, A. C. (2003). A contingency perspective on organizational learning: integrating environmental context, organizational learning processes, and types of learning. *Management Learning, 34*(1), 63-89. https://doi.org/10.1177/1350507603034001131

Göhlich, M., Schröer, A., & Weber, S. M. (2018). Organisationspädagogik–erziehungswissenschaftliche Subdisziplin und pädagogisches Arbeitsfeld. In M. Göhlich, S. Weber, N. Engel, & A. Schröer (Eds.) *Handbuch Organisationspädagogik* [*The handbook of organizational education*] (pp. 1-13). Springer. https://doi.org/10.1007/978-3-658-07512-5

Göhlich, M., & Zirfas, J. (2007). *Lernen: ein pädagogischer Grundbegriff* [Learning: a basic pedagogical concept.] W. Kohlhammer Verlag.

Günterberg, B., & Wolter, H. J. (2002). *Unternehmensgrößenstatistik 2001/2002: Daten und Fakten* [Company size statistics 2001/2002: Facts and figures] (No. 157). IfM-Materialien.

Gütschow, J., Jeffery, L., Gieseke, R., Günther, A., Gebel, R., Stevens, D., ... & Rocha, M. (2016). The PRIMAP-hist national historical emissions time series (1850-2017). *Earth System Science Data, 8,* 571-603. https://doi.org/10.5194/essd-8-571-2016

Hentze, J., Graf, A., Kammel, A., & Lindert, K. (2005). *Personalführungslehre: Grundlagen, Funktionen und Modelle der Führung* [Personnel management theory: basics, functions and models of leadership]. Haupt.

Hurrelmann, K., Becker, L., Fichter, K., Mahammadzadeh, M., & Seela, A. (2018). *Klima-LO: Klimaanpassungsmanagement in Lernenden Organisationen* [Climate adaptation management in learning organizations]. Unter.

Iturriza, M., Labaka, L., Ormazabal, M., & Borges, M. (2020). Awareness-development in the context of climate change resilience. *Urban Climate, 32*, 100613.

Institute for Ecological Economic Research (2012). Dialog zur Klimaanpassung [Dialogue of climate adaptation]. Retrieved from https://www.ioew.de/dialoge-zur-klimaanpassung-risikomanagement-in-unternehmen/

Iqbal, Q., & Ahmad, N. H. (2021). Sustainable development: The colors of sustainable leadership in learning organization. *Sustainable Development*, 29(1), 108-119. https://doi.org/10.1002/sd.2135

Kim, K. (2021). A measure of adaptive performance and the DLOQ. *The Learning Organization, 28*(4), 397-412. https://doi.org/10.1108/TLO-03-2020-0047

Kind, C., Protze, N., Savelsberg, J., Lühr, O., Ley, S., Lambert, J., & Prognos, A. (2015). *Entscheidungsprozesse zur Anpassung an den Klimawandel in Kommunen* [Decision-making processes for adaptation to climate change in municipalities]. Umweltbundesamt.

Linnenlücke, M. K., Griffiths, A., & Winn, M. I. (2013). Firm and industry adaptation to climate change: a review of climate adaptation studies in the business and management field. *Wiley Interdisciplinary Reviews: Climate Change*, 4(5), 397-416.

Lloria, M. B., & Moreno-Luzon, M. D. (2014). Organizational learning: Proposal of an integrative scale and research instrument. *Journal of Business Research, 67*(5), 692-697. https://doi.org/10.1016/j.jbusres.2013.11.029

López-Cabrales, Á., Real, J. C., & Valle, R. (2011). *Relationships between human resource management practices and organizational learning capability: The mediating role of human capital.* Personnel Review. https://doi.org/10.1108/00483481111118658

Luhmann, N. (1984). *Soziale Systeme: Grundriss einer allgemeinen Theorie* [System Theory]. Suhrkamp.

Mahammadzadeh, M., Chrischilles, E., & Biebeler, H. (2013). *Klimaanpassung in Unternehmen und Kommunen: Betroffenheiten, Verletzlichkeiten und Anpassungsbedarf* [Climate Adaptation in Companies and Communities: Affectedness, Vulnerability and Adaptation Needs] (No. 83). IW-Analysen.

Marsick, V. J., & Watkins, K. E. (2003). Demonstrating the value of an organization's learning culture: the dimensions of the learning organization questionnaire. *Advances in Developing Human Resources, 5*(2), 132–151. https://doi.org/10.1177/152342230300500200

Mbah, M., Brohmann, B., & Schütte, S. (2021). Transdisciplinary disposal governance–Learning and reflexion in and between organisations and through participation of the public. *Safety of Nuclear Waste Disposal, 1*, 221-223. https://doi.org/10.5194/sand-1-221-2021

Meinel, U., & Höferl, K. M. (2017). Non-adaptive behaviour in the face of climate change: First insights from a behavioural perspective based on a case study among firm managers in alpine Austria. *Sustainability, 9*(7), 1132. https://doi.org/10.3390/su9071132

Meinel, U., & Schüle, R. (2018). The difficulty of climate change adaptation in manufacturing firms: Developing an action-theoretical perspective on the causality of adaptive inaction. *Sustainability, 10*(2), 569. https://doi.org/10.3390/su10020569

Mertler, C. A., Vannatta, R. A., & LaVenia, K. N. (2021). *Advanced and multivariate statistical methods: Practical application and interpretation.* Routledge. https://doi.org/10.4324/9781003047223

Michel, J. S., Pichler, S., & Newness, K. (2014). Integrating leader affect, leader work-family spill over, and leadership. *Leadership & Organization Development Journal, 35*(5), 410–428. https://doi.org/10.1108/LODJ-06-12-0074

Montada, L., Kals, E., & Becker, R. (2014). *Umweltschützende Informations- und Zahlungsbereitschaften. Zusammenstellung sozialwissenschaftlicher Items und Skalen* [Environmental information and willingness to pay. Compilation of social science items and scales]. ZIS. https://doi.org/10.6102/zis67

Nerdinger, F. W., Blickle, G., Schaper, N., & Schaper, N. (2008). *Arbeits-und Organisationspsychologie* [Organizational psychology] (Vol. 429). Springer.

Nicolletti, M., Lutti, N., Souza, R., & Pagotto, L. (2019). Social and organizational learning in the adaptation to the process of climate change: The case of a Brazilian thermoplastic resins and petrochemical company. *Journal of Cleaner Production, 226*, 748-758. https://doi.org/10.1016/j.jclepro.2019.04.058

Nonaka, I., & Takeuchi, H. (1996). The knowledge-creating company: How Japanese companies create the dynamics of innovation. *Long range planning, 4*(29), 592.

Orsato, R. J., Barakat, S. R., & de Campos, J. G. F. (2017). Organizational adaptation to climate change: learning to anticipate energy disruptions. *International Journal of Climate Change Strategies and Management, 9*(5), 645-665. http://dx.doi.org/10.1108/IJCCSM-09-2016-0146

Park, S., & Kim, E. J. (2018). Fostering organizational learning through leadership and knowledge sharing. *Journal of Knowledge Management, 22*(6), 1408-1423. https://doi.org/10.1108/JKM-10-2017-0467

Pörtner, H. O., Roberts, D. C., Adams, H., Adler, C., Aldunce, P., Ali, E., & Stevens, N. (2022). Climate change 2022: impacts, adaptation, and vulnerability. Contribution of working group II to the sixth assessment report of the intergovernmental panel on climate change.

Rauh, J., & Paeth, H. (2011). Anthropogener Klimawandel und Weinwirtschaft – Wahrnehmung und Anpassungsmaßnahmen fränkischer Winzer auf den Wandel klimatischer Bedingungen [Anthropogenic climate change and the wine industry]. *Berichte zur deutschen Landeskunde* [*Reports on German regional studies*] *85*(2), 151-177.

Risher, J., & Hair Jr, J. F. (2017). The robustness of PLS across disciplines. *Academy of Business Journal, 1*, 47-55.

Rupčić, N. (2018). *Intergenerational learning and knowledge transfer–challenges and opportunities.* The Learning Organisation. https://doi.org/10.1108/TLO-11-2017-0117

Schlüter, A. (2018). Individuelle Akteure als Gegenstand der Organisationspädagogik [Individual actors as the subject of organizational education]. In M. Göhlich, S. Weber, N. Engel, & A. Schröer (Eds.) *Handbuch Organisationspädagogik* [The handbook of organizational education] (pp. 407-417). Springer VS, Wiesbaden. https://doi.org/10.1007/978-3-658-07512-5

Schönbein, D., Keupp, L., & Paeth, H. (2020). *Dossier Klimawandel* [Dossier climate change]. Retrieved June 15, 2021 from https://bigdata-at-geo.eu/klimabericht//

Senge, P. M. (1990). *The art and practice of the learning organization* (Vol. 1). Doubleday.

Stocker, T. (2014). *Climate change 2013: the physical science basis: Working Group I contribution to the Fifth assessment report of the Intergovernmental Panel on Climate Change.* Cambridge university press.

Souza, R., Sousa, S., & Nunes, E. (2020). Developing organisational learning through QC story. *Total Quality Management & Business Excellence, 31*(13-14), 1565-1587. https://doi.org/10.1080/14783363.2018.1490641

Statista. (2020). *Dossier Klimawandel* [Dossier climate change]. Retrieved June 15, 2021 from https://de.statista.com/statistik/studie/id/41248/dokument/klimawandel- statista-dossier/

Sump, F., & Yi, S. (2021). Different reasons for different responses: A review of incumbents' adaptation in carbon-intensive industries. *Organization & Environment, 34*(2), 323-346. https://doi.org/10.1177/1086026619893990

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education, 48*(6), 1273-1296. https://doi.org/0.1007/s11165-016-9602-2

Theobald, A. (2016). *Praxis Online-Marktforschung: Grundlagen–Anwendungsbereiche–Durchführung* [Practice online market research: basic application areas-implementation]. Springer-Verlag.

Teo, H. H., Wang, X., Wei, K. K., Sia, C. L., & Lee, M. K. (2006). Organizational learning capacity and attitude toward complex technological innovations: An empirical study. *Journal of the American Society for Information Science and Technology, 57*(2), 264-279. https://doi.org/10.1002/asi.20275

Tuten, T. L., Urban, D. J., & Bosnjak, M. (2002). Internet surveys and data quality: A review. *Online Social Sciences, 1*, 7-26.

Umweltbundesamt. (2022). *Emissionsquellen* [Emission sources]. Retrieved January 11, 2021 from https://www.umweltbundesamt.de/themen/klima-energie/treibhausgas-emissionen/emissionsquellen

Weber, S. M., Göhlich, M., Schiersmann, C., & Schröer, A. (2011). Organisation und Führung–Organisationspädagogische Verhältnisbestimmungen [Organisation and leadership-organizational pedagogical relationship determinations]. In M. Göhlich, S. Weber, C. Schiersmann & A. Schröer (Eds.), *Organisation und Führung* [*Organisation and Leadership*] (pp. 9-26). VS Verlag für Sozialwissenschaften. https://doi.org/10.1007/978-3-531-93298-9

Weber, S. M., Schroder, C., Truschkat, I., Peters, L., & Herz, A. (2019). Organisation und Netzwerke: Eine Einleitung [Organization and Networks: An Introduction]. In Weber, S.M., Schroder, C., Truschkat, I., Peters, L., Herz, A. (Eds.), *Organisation und Netzwerke* [*Organisation and Networks*] (pp. 1-18). Springer VS, Wiesbaden. https://doi.org/10.1007/978-3-658-20372-6

Zollo, M., Cennamo, C., & Neumann, K. (2013). Beyond what and why: Understanding organizational evolution to-wards sustainable enterprise models. *Organization & Environment, 26*(3), 241–259. https://doi.org/10.1177/1086026613496433

Appendix A. Structure and items for manufacturing companies (M), non-manufacturing companies (NM) and handicraft companies (H)